REMARKS

Claims 1-3 have been amended to address the issues raised in the rejection under 35 U.S.C. §112, first paragraph, and to clarify the geometric configuration of the scintillator and the photomultiplier tubes of the claimed PET detector. Claims 4 and 5 have been canceled. Support for these amendments can be found throughout the specification (*e.g.*, see paragraphs [0017], [0026], and [0030]) and in Figure 1. No new matter has been added. Upon entry of this amendment, claim 1-3 and 6-9 will be in the application.

Claim Rejections – 35 U.S.C. §112, First paragraph

Claims 1-3 and 6-9 stand finally rejected under 35 U.S.C. §112, first paragraph, as allegedly not providing enablement for all scintillators that have a decay time constant of less than 35 ns and a light output at least equal to that of NaI(T1). The claims have been limited to the $LaBr_3$ or $LaCl_3$ scintillators that are specifically described in the specification and previously claimed in claims 4 and 5, thereby providing clear enablement for all claims. Claims 4 and 5 have been canceled. Withdrawal of the rejection of claims 1-3 and 6-9 under 35 U.S.C. §112, first paragraph, is respectfully solicited.

Claim Rejections – 35 U.S.C. §103

Claims 1-7 and 9 stand finally rejected under 35 U.S.C. §103(a) as allegedly being obvious over Van Loef (*High-Energy-Resolution Scintillator: Ce^{3+} Activated $LaBr_3$*) in view of Cho et al. (USP 4,980,552). Also, claim 8 stands finally rejected under 35 U.S.C. §103(a) as allegedly being obvious over Van Loef (*High-Energy-Resolution Scintillator: Ce^{3+} Activated $LaBr_3$*) and Cho et al. (USP 4,980,552) further in view of Cherry (USP 6,552,348). These rejections are respectfully traversed in view of the claim amendments.

As noted in the previous response, the claims are directed to a PET detector and a corresponding PET scanner and scanning system. The claimed PET detector includes a plurality of photomultiplier tubes arranged with respect to a plurality of scintillator crystals where multiple scintillators provide light output to each photomultiplier tube and where the scintillator crystals and said photomultiplier tubes are arranged respectively peripherally around a cavity for accepting a patient. In exemplary embodiments, the scintillator has a decay time constant $\tau \leq 35$ ns and a light output at least equal to the light output of NaI(Tl). The PET scanning system further includes a time stamp circuit that records the time of

receipt of gamma rays by respective PET detectors and provides timing data outputs and a processor that receives the timing data outputs, calculates time-of-flight (TOF) of gamma rays through a patient in the cavity, and uses the TOF of gamma rays in the reconstruction of images of the patient. This configuration simultaneously provides high sensitivity and spatial resolution so as to enable a time-of-flight PET scanning system that has heretofore been unavailable in the art. Such a PET detector and scanning system are not shown or suggested by the references cited by the Examiner.

Van Loef

Van Loef's paper discloses the basic properties of LaCl and LaBr. The reported results demonstrate very good energy resolution and timing resolution. However, these initial measurements were performed with a small crystal (3 x 10 mm) directly coupled to a PMT. A PET detector for TOF requires both very good energy resolution and timing resolution as well as good spatial resolution and high sensitivity. Van Loef does not address the issues of good spatial resolution and high sensitivity needed for time-of-flight PET. For time-of-flight PET, the inventors needed to develop a detector with position encoding (many crystals coupled to a light-guide and array of PMTs) using crystals with sufficient length (e.g., 30-mm) so as to achieve good sensitivity for 511 keV gammas while still retaining good energy and timing resolution. Van Loef did not suggest how to do this or even if it could be done. The Examiner is asked to note that the timing response of a crystal configured for a PET application with a narrow aspect ratio (e.g., 4mm x 4mm x 30mm) is very different than that of the crystal used by Van Loef, and the timing resolution of a detector that incorporates light sharing would be expected to be inferior to the configuration described by Van Loef (crystal coupled directly to PMT). In fact, Van Loef did not specifically suggest that his crystal could be applied to TOF PET, instead referred to LSO (in the beginning of the article) as being a good candidate for PET because of its higher density. Van Loef states at the very end of the article: "For applications where a good energy resolution is required in combination with a fast luminescence decay, LaBr may be the ultimate choice." However, good energy resolution plus fast decay does not add up to time-of-flight PET or the claimed PET detector, corresponding PET scanner or PET scanning system.

In the Final Rejection, the Examiner acknowledges that Van Loef does not disclose a plurality of photomultiplier tubes and scintillator devices arranged in a PET detector where

the scintillator crystals and PMTs are arranged around the periphery of the cavity where a patient is accepted as claimed. For such teachings, the Examiner turns to the patent to Cho et al. Claims 1-3 have been amended to clearly distinguish over such a configuration.

Cho

Cho discloses the use of collimation with large detectors in order to achieve high resolution in PET. The potential advantages are the reduction in the number of electronic channels and the number of individual crystal elements (pixels). The disadvantage is that collimation reduces sensitivity. Cho mentions time-of-flight (TOF) several times and mentions the use of barium fluoride as a fast scintillator. However, Applicant notes that one of the limitations of early TOF systems (in 1980's) with barium fluoride was that they could not achieve high spatial resolution due to the low light output of the scintillator which precluded making a detector with good position encoding. Cho's idea to use a large detector with collimation addressed this problem, although those skilled in the art would appreciate that Cho's system would not be practical for TOF since collimation sacrifices sensitivity - exactly what TOF is intended to improve. Cho's system proves a one-to-one correspondence between the scintillator crystals and PMTs (see Figure 3) and is unable to discriminate small crystals since the collimator measures a single position and measures different positions only as the collimator is moved through the field of view, thereby significantly reducing sensitivity.

By contrast, the inventors are able to simultaneously provide high sensitivity (*e.g.*, 30 mm long crystals) and high spatial resolution (*e.g.,* 4 mm wide crystals) by developing a TOF detector which uses many narrow crystals with position encoding - which is possible because LaBr has both high light output and fast timing. The amendments to claims 1-3 capture this distinction by now claiming that the plurality of photomultiplier tubes are arranged with respect to the plurality of scintillator crystals so that each photomultiplier tube receives light output from several of the scintillator crystals and the scintillator crystals and the photomultiplier tubes are arranged respectively peripherally around the cavity.

As a result of this configuration for scintillators with very good energy resolution and timing resolution, the necessary sensitivity and spatial resolution for TOF PET become possible. One skilled in the art would not have used the Van Loef scintillator in the Cho PET configuration to "increase detection efficiency" as the Examiner alleges, for such a

configuration would decrease system sensitivity and be ineffective for TOF PET. In any case, Cho does not teach the claimed configuration. Withdrawal of the rejection of claim 1-7 and 9 over Van Loef and Cho is respectfully solicited.

Cherry

Cherry is cited only with respect to claim 8 for the purported teaching of a light guide between the PMT and scintillator crystals for optical coupling. The Examiner is asked to note that neither the scanner configuration nor detector taught by Cherry is suitable for TOF, so even if one would have been motivated to combine the teachings of Cherry with Van Loef and/or Cho, the afore-mentioned shortcomings in the teachings of Van Loef and Cho would not be overcome. Withdrawal of the rejection of claim 8 over Van Loef, Cho and Cherry is respectfully solicited.

Conclusion

The invention of amended claims 1-3 and 6-9 is not shown or suggested by the cited prior art. The present application is thus believed to be in condition for allowance. A Notice of Allowability is respectfully solicited.

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/Michael P. Dunnam/
Michael P. Dunnam
Registration No. 32,611

Woodcock Washburn LLP
One Liberty Place - 46th Floor
Philadelphia PA 19103
Telephone: (215) 568-3100
Facsimile: (215) 568-3439